If anything be evolved by evolution it is evident that, whatever its nature may be, it must cease to be evolved if it would maintain its integrity. For inertia of matter and conservation of force apply to bodies which no longer are undergoing evolution. Variation, as a process of becoming different, is a characteristic of living bodies, and, though it is not doubted that in the phenomena of variation it is ordinary chemical and physical matter which exhibits the peculiar vital phenomena, we have no reason to suppose that the operations of physics and chemistry are thus variable.

H. S. WILLIAMS.

YALE UNIVERSITY.

MICROSCOPICAL EXAMINATION OF WATER, WITH A DESCRIPTION OF A SIMPLE FORM OF APPARATUS.

THE microscopical examination of water is becoming every year a matter of greater interest, and the study of the minute aquatic plants and animals is more and more attracting the attention of scientists. These organisms are interesting for several reasons and, besides recognizing their importance in the domain of pure science, we are beginning to appreciate the great part that they play in nature and their effect, direct and indirect, upon the human being. Their presence in surface waters is often the cause of much harm when the water is used for purposes of domestic supply; scores of instances may be mentioned where they have rendered the water entirely unfit for use. On the other hand, their presence in ponds and streams is of importance to the fish-culturist because they form the fundamental source of the food supply of fishes; this is probably true both of salt and fresh water.

Because of this connection between the number of microscopical organisms in a cubic centimeter of water and the price of fish in our markets, the study of the 'plankton,' *i. e.*, the floating micro-organisms, is being emphasized on both sides of the Atlantic. Observers are beginning to trace the connection between the presence of microscopical organisms and the abundance of fish in our lakes, and valuable comparisons have been made between the stomach and intestinal contents of fishes and the organisms found in the water where the catches were made. This work is of very great importance and should be vigorously pursued by our fish commissions. To be of the greatest value it should extend well over the country and include lakes and ponds sufficiently different in character to enable one to determine the laws governing the nature and distribution of the plankton in various climates and under various conditions. The study ought not to be carried on spasmodically, as, for instance, during the short vacation of some college professor who generously gives his time and talents to the cause, but should be undertaken seriously and continued throughout the whole year. Only in this way can we obtain the data necessary for a complete understanding of the subject.

Since water works managers are equally interested in the microscopical organisms found in surface waters, and up to the present time have been responsible for most of the work done upon the subject, it might be possible for fish commissions, boards of health, water-works superintendents, and others interested, to work together according to a definite concerted plan, sending their results to some central commission or committee for comparison and study. Such an extended biological study taken in connection with meteorological records and observations upon the temperature, transparency, etc., of the water would be of very great value. And it would seem that we have little excuse for neglecting to cultivate this fruitful field of research. Vast num-

bers of microscopical examinations are now being made [during the past eight years more than 40,000 have been made in Massachusetts alone], and the rapid growth of the new science of sanitary biology is developing numbers of well-trained observers wide awake to the value of these problems and well able to undertake the work. What is needed is cooperation.

Various methods have been employed from time to time for determining the character and amount of microscopic life in water. Those interested in the subject from the piscatorial standpoint have usually employed some sort of net for straining the organisms from the water and concentrating them for the microscope. One of the best devices of this kind is that devised by Professor Reighard and used with good results for studying the plankton in Lake Michigan. It consists of a conical net of fine bolting cloth, at the small end of which there is a 'bucket,' made by covering a metal framework with some of the same bolting cloth. The apparatus is hauled through the water, filtering a column of water whose cross section is the same as the circular mouth of the net and whose length is equal to the distance through which the net is hauled. The organisms are caught by the fine bolting cloth and are ultimately washed into the bucket. The collected material is then removed by an ingenious arrangement, measured and sent to the laboratory for microscopical examination. By this method one is enabled to get a good idea of the total amount of suspended matter in the water, but it can hardly be called an accurate method of obtaining the number of living organisms present, as the net sweeps in amorphous matter as well as organisms and some of the smaller forms undoubtedly escape through the bolting cloth. Moreover, the amount of water actually filtered cannot be told with a great degree of accuracy. Nevertheless, the method is one of value, particularly for securing the larger and rarer forms of rotifers, crustacea, etc.

Sanitarians who have studied the microscopical organisms in water supplies have usually employed very different methods from the above, partly because they have been interested more especially in the smaller forms, but chiefly because their operations have been confined to the small quantities of water sent to the laboratories for analysis. During the last decade the old methods of sediment examination have given way to the filtration methods. The Sedgwick-Rafter method, which is most used at the present time in laboratories of water analysis, is carried on as follows :

A portion of the water to be examined is measured out in a graduate and filtered through a thin layer of quartz sand placed at the bottom of a glass funnel upon a perforated rubber stopper, the hole in which is capped with a disc of bolting cloth. When the water has filtered, the organisms will be found upon the sand, while the filtered water will be free from them. The rubber stopper is then removed and the sand washed into a test tube, with a measured quantity of distilled water delivered from a pipette. Usually 250 or 500 c. c. of the sample are filtered and the sand washed with 5 c. c. The test tube is then thoroughly shaken and the water decanted into a second tube ; the organisms being lighter than the sand, will pass off with the water, leaving the sand clean upon the walls of the first tube. In this way the organisms are concentrated 50 or 100 times. One c. c. of this concentrated fluid is then transferred to a counting cell, which just holds it and which has a superficial area of 1,000 sq. mm. After putting a thin glass cover-slip over this cell it is transferred to the stage of the microscope for examination. The eye-piece of the microscope is fitted with a micrometer in the shape of a ruled

square of such a size as to cover one sq. mm. on the stage, *i. e.*, one thousandth of the entire area of the cell. The organisms observed within the limits of the ruled square are then counted and the cell moved until another portion comes into view, when another count is made. Thus 10 or 20 squares are counted and the number of organisms present in the sample calculated.

This process has many things to be said in its favor, and it is undoubtedly the best all-around method for the study of the plankton. The apparatus required is simple, inexpensive and not liable to get out of order. The process is neither long nor difficult, and if care and cleanliness are observed in the manipulation very accurate results may be obtained. Ordinarily the quantity of water operated upon is small, but there is no reason why large filters may not be used. The writer has frequently used a funnel having a neck one inch in diameter, filtering from 1,000 to 10,000 c.c. This, when used with an aspirator to hasten the filtration, has given excellent satisfaction. The chief objection to the Sedgwick-Rafter method is that delicate organisms are liable to be crushed upon the sand, and this danger is naturally somewhat greater when this aspirator is used. It is probably no greater, however, than in Reighard's net.

Recently a new apparatus has been devised for the study of the microscopical organisms, known as the planktonikrit. This is a modification of the centrifugal machine and depends upon the fact that the specific gravity of the organisms is different from that of water. It has the advantage of avoiding, to a certain degree, the crushing of the delicate infusoria, but it is somewhat inaccurate in the case of some of the lighter organisms; furthermore, it operates upon very small quantities of water.

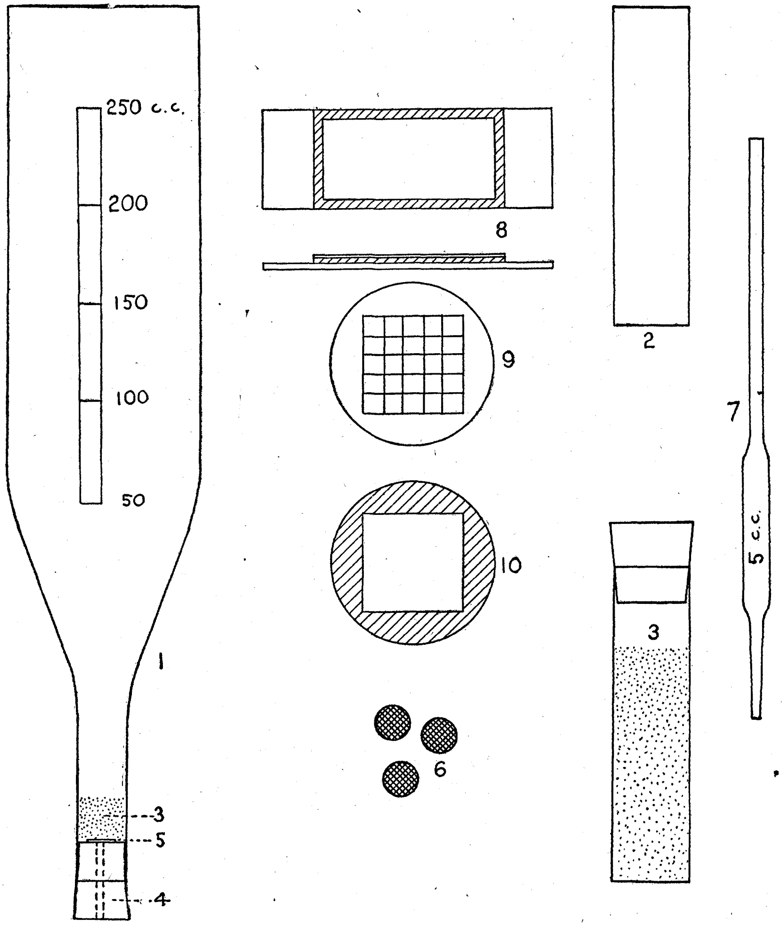
In a complete study of the microscopical organisms, such as might be undertaken on cur great lakes, for example, it would be advisable to use all three methods, adopting the Sedgwick-Rafter method for general quantitative work, but using the net and centrifugal apparatus for determining the rare and delicate organisms.

As there are many lovers of the microscope who are interested in studying aquatic life, and as there are many others connected with water-works to whom the study of algæ and infusoria would be of much value, the writer has tried to reduce the Sedgwick-Rafter method to its simplest possible elements in order that it may be more generally used. Furthermore, it is often necessary for the sanitary biologist to be provided with a portable outfit for work in the field. There are many fragile organisms which will not bear transportation to the laboratory. Uroglena, for example, a very important and troublesome organism found in water supplies, goes to pieces completely when kept for a short time in a stoppered bottle. It is, therefore, necessary to make the examination of water immediately after the collection of the sample.

The chief modification of the method for field work consists in the use of a cylindrical glass funnel [Fig. 1] similar to the one designed by Mr. D. D. Jackson for the Massachusetts State Board of Health, but differing from it in having a capacity of 250 instead of 500 c.c., and in having graduations marked upon the sides. This funnel may be conveniently carried and its graduation renders the use of a second measuring glass unnecessary. When in use it may be supported on a wire frame, which any ingenious person can make. In place of the test-tube it has been found convenient to use tube vials [Fig. 2] having square ends. These require no racks and are not easily tipped over. The pipette for washing the sand might be dispensed with if one of the tube vials was graduated, but as much depends upon ac-

curacy in concentrating the sample it is best to use a short pipette [Fig. 7]. The sand [Fig. 3] used in the filter should be perfectly clean and of such size that its grains will pass through a sieve having 60 meshes to the inch, but not through one having 100 meshes. Crushed quartz makes the best filtering material and should be used when obtainable. The discs of bolting cloth [Fig. 6] may be easily cut out with a wad cutter. The filtered water may be used for concentrating the organisms, or it is possible to employ preservative fluids in case the microscopical examination must be deferred or it is desired to keep the specimens. The cell [Fig. 8] for holding the concentrated fluid may be made by cementing a brass rim to an ordinary glass slip. It should be 50 mm. long, 20 wide and 1 mm. deep, thus holding just 1 c.c. and having a superficial area of 1,000 sq. mm.

A very simple microscope will answer for this work. A large stand is too valuable and too heavy for the rough usage in the field, and a cheap, light stand with a $\frac{1}{2}''$ or $\frac{2}{3}''$ objective and a No. 3 ocular will answer equally well. The ocular must be provided with a micrometer, so that the observer may count the number of organisms in one cu. mm. of the cell. A disc of glass ruled as in Fig. 9 is the best form of micrometer,



but a piece of thin metal with a square cut out, as shown in Fig. 10, may be substituted. In either case the square must be of such a size that it covers one sq. mm. on the stage with a given combination of objective and ocular, and a certain tube length to be found by comparison with a stage micrometer. It is an advantage to have at hand higher powers for a more thorough study of the organisms met with, but for ordinary work the powers suggested are sufficient.

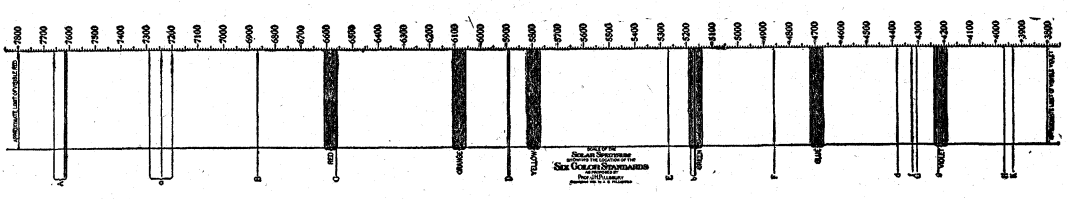
All this apparatus, together with bottles for collection and note book for records may be carried in a grip sack, and this will be found generally the most convenient way. It is possible, however, to make a neat box, with compartments for holding the microscope, funnels, tube vials, etc., and I respectfully submit this to manufacturers of microscopical supplies.

GEORGE C. WHIPPLE.

NEWTON CENTRE, MASS.

SPECTRUM COLOR STANDARDS.

THE extensive adoption of the *color standards* proposed by me and put into practical form for educational purposes by Mr. Milton Bradley, of Springfield, Mass., leads me to offer the readers of SCIENCE an opportunity to examine a chart of the solar spectrum after Rowland with the standard colors located upon it. The importance of making the spectrum the basis of all our work in color is recognized by all, and I have received many appreciative communications from eminent men in scientific and educational circles, both in this country and England, expressing approbation of the effort to bring our now greatly confused color nomenclature within some accurate and practical system. The idea of teaching color by a system thus definitely defined has also proved to be very practical, not only in elementary instruction, but in the more exacting art work. This rapidly increasing public interest in the subject makes it seem likely that the accompaning chart will be of interest.



A few observations on the practical application of these standards will illustrate the value of the scheme. The area representing each particular standard in the chart is narrow enough to allow of no perceptible difference in the hue of the two sides of the area when viewed through the spectroscope and is still wide enough to give a clear working field. Moreover, the areas selected coincide with the views of a large number of persons experienced in the discrimination of color and well prepared, therefore, to judge what would be of practical value as color standards and applicable to the various needs of the arts as well as to science and to educational purposes. And still again, though there was no direct reference to the theories of color vision, these standards having been first proposed nearly fifteen years since, the standards prove to have been happily selected as regards the more recent theories of color vision. Another very important consideration is the fact that the quality of any color which I have yet seen can be obtained by the union of two of these standards. Of course, the intensity of one of the two compared colors will generally have to be modified to obtain a perfect match, but I have never yet been unable to do this. In a